

Break up of droplets in time-dependent flow

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Introduction

Properties of blends depend largely on the microstructure, which is the result of break up and coalescence during processing. The objective of the present study is to determine the effect of time-dependent flow conditions and visco-elastic behavior on the deformation and break up of droplets.

Experimental Methods

A single Newtonian or visco-elastic droplet is subjected to a Newtonian hyperbolic flow, using an opposed jets device, as shown in figure 1.

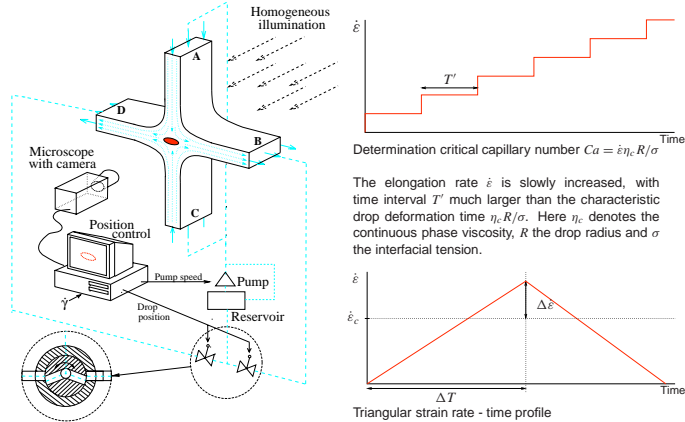


fig. 1 Experimental setup and strain rate profiles applied

In quasi steady flow, the critical capillary number is determined, which defines the critical elongation rate $\dot{\epsilon}_c$ at which a stable drop shape no longer exists. To study the droplet behavior in a more realistic flow, a triangular strain rate - time profile is applied, varying the rheological properties of the phases as well as the parameters ΔT and $\Delta \dot{\epsilon}$ (see figure 1).

Results

Experiments have been performed using a visco-elastic drop ($R=1.23$ mm, 1.65 wt% PEO 5e6 in H_2O) dispersed in silicon oil ($\eta_c = 10$ Pa·s), which has a critical deformation $D_c \approx 0.35$ (figure 2).

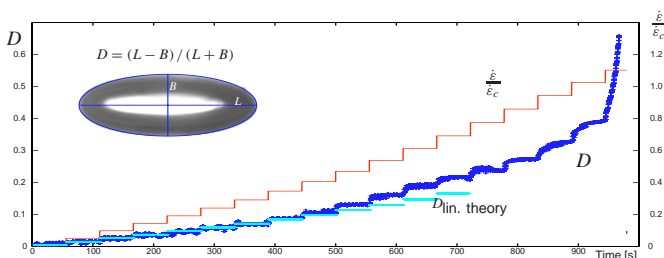


fig. 2 Deformation in quasi steady flow

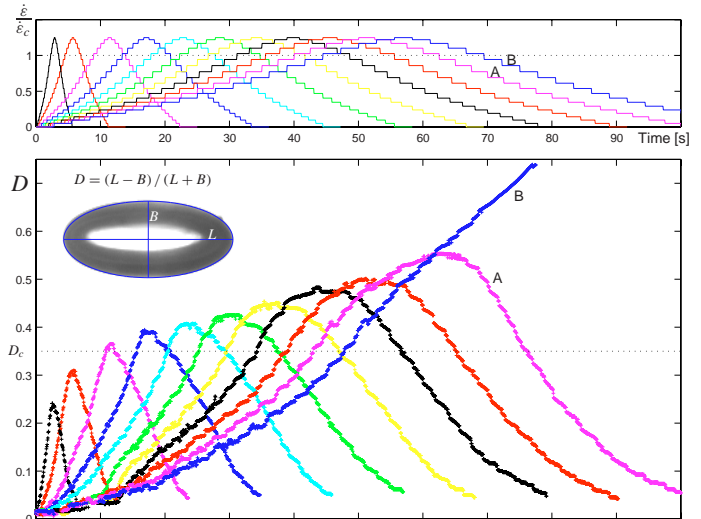


fig. 3 Droplet deformation, applying a triangular strain rate profile with $\Delta \dot{\epsilon} = 0.25 \dot{\epsilon}_c$ and $\Delta T = 2.7, 5.6, 11, 17, 22, 28, 33, 39, 44, 50,$ and 56 s.

Applying triangular strain rate - time profiles with $\Delta \dot{\epsilon} = 0.25 \dot{\epsilon}_c$ and various ΔT , it is found that at small ΔT , the droplet can not respond fast enough to reach this deformation D_c , see figure 3. As ΔT is increased, the droplet reaches more elongated shapes with $D > D_c$, though break up does not occur. As is shown in figure 4, the drop will break up if ΔT exceeds a critical value.

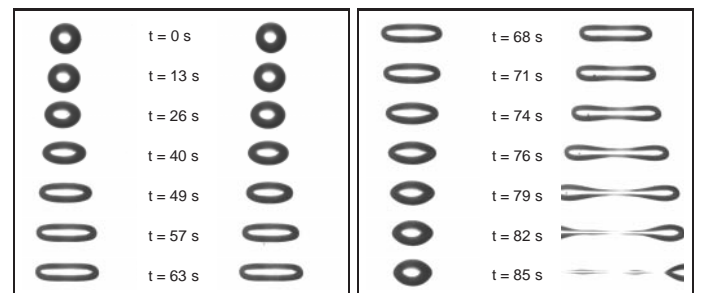


fig. 4 Droplet response to the triangular strain rate - time profiles A (left, $\Delta T = 50$ s) and B (right, $\Delta T = 56$ s) of figure 3

Future Work

- ◇ Experimental examination of:
 - ★ the influence of visco-elasticity
 - ★ the critical values of parameters ΔT , $\Delta \dot{\epsilon}$
- ◇ Numerical analysis of the response of a droplet to time-dependent strain rate profiles

Acknowledgements

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